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Fractionation, Physicochemical Analysis, and Oil Extraction Efficiency of Melon Seeds

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Annotation: Melon seeds are considered a promising oil-bearing raw material, containing 30–40% lipids and 34–39% proteins on a dry matter basis [1]. Therefore, the processing of melon seeds enables the expansion of the range of vegetable oils belonging to the linoleic group, in which the content of unsaturated fatty acids reaches up to 85% [2]. This is of particular importance for healthy human nutrition, as animal fats still predominate in the daily diet of the world population.

Introduction

The technological properties of melon seeds as an oil-bearing raw material are determined by their physico-mechanical, physico-chemical, and chemical composition [9, 10, 11], and these properties have been investigated by many researchers [3–8]. These characteristics are crucial for the development of efficient technologies for obtaining vegetable oil and high-protein press cake, as well as for substantiating the selection and design requirements of processing equipment.

When analyzing scientific and technical sources devoted to the study of the chemical properties of melon seeds as a processing object for obtaining high-quality vegetable oil and high-protein press cake, it is necessary to consider not only the general chemical composition of the seeds but also the available data on their fruit hull (seed coat). However, information on the chemical characteristics of the melon seed hull is extremely limited [12, 13]. This is apparently due to the fact that melon seeds were not intended to be processed without prior separation of the hull.

The distribution of components in melon seed hulls is as follows: nitrogen-containing substances – 3.0%, lipids – 0.6%, nitrogen-free extractive substances and fiber – 94.6%, and ash – 1.8%

[14]. These data indicate that the lipid content in the melon seed hull is very low, whereas nitrogen-free extractive substances and fiber account for up to 95% of the total mass. These components act as unnecessary ballast and deteriorate the quality of the resulting press cake.

In this study, research was carried out to substantiate the feasibility of obtaining high-quality oil products and high-protein press cake from melon seeds, as well as to assess the possibility of separating the seed hull from the residual material after processing.

Materials and Methods

Thus, a review of studies on the physico-mechanical properties of melon seeds cultivated and investigated in various regions of the world shows that, in the Republic of Uzbekistan, the physico-mechanical characteristics of seeds of two zoned melon varieties—"Obi Novvot Samarkandskaya mestnaya" and "Oq urug'"—have not yet been sufficiently studied. Therefore, these two varieties were selected as the objects of the present study. Seed samples with a moisture content of 15% were used for the experiments.

The average specific fracture characteristics of the melon seed mixture were determined based on a sample of 200 seeds taken from a commercial batch. The seeds were positioned relative to the applied crushing force in three orientations—flat position, edgewise, and along the height (longitudinal axis)—and the force required to achieve complete fracture was recorded.

Each melon seed sample was separated into fractions using sieves with diameters of 5 mm, 6 mm, and 7 mm. Subsequently, each fraction was weighed and its mass proportion in the mixture was determined. Weighing was performed using an 81-620CE balance (Japan) with an accuracy of 0.01 g.

The average mass of a single seed in each fraction was calculated using the following relationship:

$m_{o‘rt} = m_{fr}/n$

where $m_{o‘rt}$ is the average mass of one seed in the fraction (kg), m_{fr} is the total mass of the fraction (kg), and (n) is the number of seeds in the fraction (pieces).

Using an electronic caliper with an accuracy of 0.01 mm, the length, width, and thickness of each melon seed were measured. Thereafter, impact loading was applied using a 50 g weight. The lifting height of the weight required to fracture the seed coat was recorded using a measuring scale. Each seed was fractured by dropping the weight from different heights. For each fraction, the average lifting height of the weight was determined and the mass-weighted average height $H_{o’rt}$ was calculated. Based on this, the work required to fracture a single seed, A (J), was calculated as:

$A = H_{o‘rt} \cdot R$

where $H_{o‘rt}$ is the lifting height of the weight (m) and (R) is the mass of the weight (kg).

For each fraction of 1 kg of melon seeds, the average specific fracture work (A_g) (J/kg) was determined using the following equation [15]:

$Ag = 1000 \cdot A / ms$

where (A) is the work required to fracture a single seed (J) and (ms) is the average mass of one seed (kg).

$$A_{Aralash} = \sum_{i=1}^{n} X_i \times A_i$$

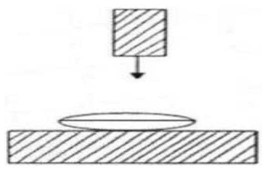
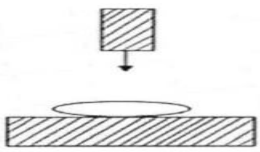
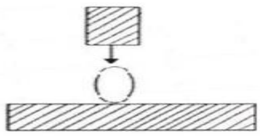
where: X_i- mass fraction of the i-th fraction in the mixture;

- ✓ Ai – specific fracture (crushing) work of the i-th fraction;

- ✓ n– number of fractions.

The investigation of the **specific fracture work of the melon seed mixture** was carried out according to the methodologies described in [16–19]. During the study, the specific fracture work of seeds of the **"Obi Novvot Samarkandskaya mestnaya"** and **"Oq urug'"** varieties was examined depending on the direction of the dynamic load applied to the seed. The loading orientations included the **flat position, edgewise position,** and **along the longitudinal axis** (Figure 1).

Figure 1. Types of directions of dynamic loading acting on the seed.

1 – Direction of dynamic loading applied to the seed (**flat position**)	
2 – Direction of dynamic loading applied to the seed (**edgewise position**)	
3 – Direction of dynamic loading applied to the seed (**along the longitudinal axis**)	

Result and discussion

Fractionation of Melon Seeds

In order to evaluate the technological value of the commercial fraction of melon seeds (the fraction passing through a sieve with a hole diameter of 4 mm), calibration was carried out using sieves with hole diameters of 5 and 6 mm. The obtained results are presented in Table 1.

Table 1 — Fractional composition of melon seeds of the "Obi Novvot Samarkandskaya mestnaya" and "Oq urug'" varieties

Table 1 — Fractional yield of melon seed varieties, %

Melon seed varieties	**Large fraction retained on 6 mm sieve**	**Large fraction retained on 5 mm sieve**	**Fraction passing through 5 mm sieve**
"Obi Novvot Samarkandskaya mestnaya"	29.1	63.5	7.4
"Oq urug'"	25.6	50.8	23.6

As can be seen from Table 1, the main portion of the seeds, ranging from **50.8% to 63.5%,** corresponds to the fraction retained on the sieve with a **5 mm hole diameter**. The passing fraction accounts for **7.4% to 23.6%.**

The changes in the **average specific fracture work** of melon seed fractions passing through sieves with hole diameters of **4, 5, and 6 mm** at different moisture contents were investigated. The results showed that the fraction passing through the **4 mm sieve** (i.e., the fraction passing through the 5 mm sieve) exhibited the **highest average specific fracture work**, amounting to **720 J/kg.** In contrast, the fraction retained on the **6 mm sieve** had the **lowest average specific fracture work,** equal to **550 J/kg.**

According to the calculations of energy consumption depending on the **direction of dynamic loading applied to the seed**, the results of the experimental studies are presented in Table 2. These data indicate that the **minimum average specific fracture work** is observed when melon seeds are fractured **along their longitudinal axis**. A similar behavior has also been reported for sunflower seeds [20].

Table 2 — Indicators of the average minimum specific fracture work depending on the direction of dynamic loading applied to the seed.

Namlik, %	Yo‘nalish 1 (J/kg)	Yo‘nalish 2 (J/kg)	Yo‘nalish 3 (J/kg)
15	750	720	700

Conclusion

1. The main technological properties of melon seeds of the studied varieties, which are important for their processing, including the key physico-mechanical characteristics, were investigated. It was established that oil obtained from calibrated melon seeds retained on a sieve with a hole diameter of 5 mm is of higher quality than oil produced from seeds of the passing fraction.
2. The minimum average specific fracture work is achieved when the dynamic load is applied along the longitudinal axis of the melon seeds, as well as for the retained seed fraction on the 5 mm sieve and with a decrease in seed moisture content.

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